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Implementation Model of an Open Inquiry Curriculum

MICHAL ZION (zionmi@mail.biu.a.cil), *School of Education, Bar-Ilan University, Israel*

ABSTRACT *Despite the growing consensus regarding the value of inquiry-based teaching and learning, the implementation of such practices continues to be a challenge. The goal of this paper is to present a model for the educational infrastructure that can support the implementation of the Biomind program, which is a new open inquiry program for Israeli biology high school students. This model of the Biomind program implementation consists of four interactive domains, that is, Development, Operating, Supporting, and Control. Through the developmental domain, workshops were held where teachers developed the program as it was operating. Teachers' reflective discussions and the ongoing action research contributed to the development and improvement of the Biomind program. While introductory workshops served as a basis for the operation domain, the advanced workshops and forums for veteran teachers, as well as conferences, were significant factors in supporting and controlling the program implementation. This article will describe how each aspect of the model supports the implementation of the Biomind program, emphasizing the assistance provided to teachers both in comprehending the essence of open inquiry and in coping with the difficulties of teaching open inquiry.*

KEY WORDS: *Biomind, implementation, open inquiry, professional development.*

Introduction

Recent science education reforms (American Association for the Advancement of Science [AAAS], 1993; National Research Council [NRC], 1996, 2000) advocate the design of instructional environments that involve students in learning about the nature of science via scientific inquiry. The NRC (1996) describes scientific inquiry in the following terms:

> *Scientific inquiry refers to the ways in which scientists study the natural world and propose explanations based on evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (p. 23).*

In essence, because the inquiry process focuses on the 'why' and 'how', and not on the 'what' of knowledge, it attempts to activate and motivate learning (Haury, 1993; Tilgner, 1990), builds life long autonomous learners (Osborne, 1996; White, 1988), creates a learning community of students and teachers (Lim, 2004), develops flexible and adaptive thinkers (Driver, Asoko, Leach, Mortimer, & Scott, 1994; Yager, 1991), and encourages creativity and risk taking (Khishfe & Abd-El-Khalick, 2002).

Inquiry based activities encompass a broad spectrum ranging from structured and guided inquiry (teacher-directed) to open inquiry (student-directed). In the course of structured inquiry, the students investigate a teacher-presented question

through a prescribed procedure. In the course of guided inquiry, the students investigate a teacher-presented question using student designed/selected procedures. In open inquiry, the teacher defines the knowledge framework where inquiry is conducted, but leaves the students with a wide variety of possible inquiry questions. In the course of open inquiry, the students investigate topic-related questions that are student formulated through student designed/selected procedures. The students experience decision-making throughout each stage of the inquiry process. This method reflects the work done by scientists. Open inquiry demands high ordered thinking, and the key to such inquiry is the teacher's ability to bring his or her students to ask the questions that would guide them on their inquiry. Since the purpose of inquiry teaching is to guide students to construct their own knowledge, and since questioning is an important skill, engaging students in an open inquiry process is considered an important challenge.

The move from teachers who direct students in a structured inquiry to those who facilitate students in an open inquiry is a challenging endeavor for teachers to follow (Windschitl, 2002), and requires greater flexibility on the part of both teachers and students (Zion, Slezak, Shapira, Link, Bashan, Brumer, Orian, Nussinowitz, Court, Agrest, & Mendelovici, 2004b). In open-ended experimentation, students may experience difficulty with choosing problems that can be translated into hands-on science experiments, or solved with the time and resources available in school. A teacher who underestimates this difficulty may wind up with students who are confused and frustrated. Moreover, students may not see science as scientists' efforts to construct explanations for phenomena in the "real world," and may not understand that knowledge is the product of a never-ending process by which it is re-examined and updated. Students may work according to the "engineering model," instead of a "scientific model" (Schauble, Klopfer, & Ragghavan, 1991), that is, they see scientific assignments as an experience aimed at anticipated results, and plan their experiments accordingly. Moreover, students may encounter difficulty in understanding the role of control and the explanation of planning an experiment (Tamir, Stavy, & Ratner, 1998). For example, it has been shown that students, who performed inquiry work in a conservatory, acquired declarative and procedural knowledge of inquiry skills, but did not necessarily gain conceptual or logical knowledge, which is expected to be acquired in the problem-solving process (Dvir & Chen, 2000).

Students should not be left to cope with the big challenge of open inquiry by themselves. Teachers play a critical role in open inquiry learning. This role incorporates guiding, focusing, challenging, and encouraging students to engage in this kind of activity. On the other hand, there are many teaching difficulties in implementing the open-inquiry teaching approach among science teachers. Teachers may feel unconfident while facilitating students in the pedagogically risky process of open inquiry, in which results are unexpected, cannot be predetermined, and can trigger further investigations (Kennedy, 1997; Singer, Marx, & Krajcik, 2000; Windschitl, 2003). The dynamic nature of open inquiry may result in teachers feeling out of control over what is going on in their class (Uno, 1997). In order to avoid such difficulties, teachers tend to provide their students with full instructions concerning the procedure of investigation, and provide minimal opportunity for the students to design an investigation using the scientific inquiry approach (Gott

& Duggan, 1996). By doing this, teachers impair the learning community of teachers and students, functioning in association with each other to promote an open inquiry process (Zion & Slezak, 2005). Bybee and Loucks-Horsley (2001) indicated that "*Teachers need to know science as deeply, even more deeply, than their students*" (p. 4). Lack of content and procedural knowledge indicates a need for an academic support system for the teacher in order to fill in the gaps (Trautmann & MaKinster, 2005).

Those who claim that the open inquiry experience may deepen an understanding of the essence of science for future generations of students are attempting to develop different learning and teaching methods that meet this challenge (Berg, Bergendahl, & Lundberg, 2003; Roth, 1999). In this spirit, a group of Israeli biology teachers created a novel inquiry-based curriculum (program) called "Biomind" with the aim of developing scientific knowledge through inquiry teaching among eleventh- and twelfth-grade students (Zion, Shapira, Slezak, Link, Bashan, Brumer, Orian, Nussinowitz, Agrest, & Mendelovici, 2004a). The main feature of the curriculum is an autonomous and authentic inquiry learning, considered open inquiry. The "Biomind" open inquiry program can provide an exciting opportunity for science educators to enrich their understanding in the context of open inquiry learning and teaching processes. The goal of this paper is to present the educational infrastructure that supports the implementation of the Biomind program. A model which describes this educational infrastructure is presented in Figure 1, and includes developing the curriculum while operating it experimentally, conducting an action research, holding introductory workshops for teachers new on the program and advanced workshops for veteran teachers, managing online forums, meetings for program leading teachers, and conferences. This article will show how each aspect of the model supports the implementation of the Biomind program, emphasizing the assistance provided to teachers both in comprehending the essence of open inquiry and in coping with the difficulties of teaching open inquiry.

Method

The research methodology focused on a qualitative collection of evidence concerning the different aspects involved in the implementation of the Biomind program. Data were gathered during six academic school years from the first year of the establishment of the Biomind program (1999-2005). According to the qualitative paradigm, the researcher was acknowledged as the instrument through which data are collected and analyzed (Rudduck & Hopkins, 1985; Stenhouse, 1975). By attending to the educational activities that were under investigation in this research, the researcher "entered the world of her participants and, at least for a time, seeing life through her eyes" (Rager, 2005, p. 24). Protocols of teacher discussions in face to face meetings and electronic records of teacher discussions in the online forums were kept.

Feedback questionnaires were also distributed to teachers on different occasions and reviewed by the researchers. As will be elaborated later in this article, feedback and summary conversations with teachers involved in each aspect of the program implementation were also recorded. Content analysis was used for analyzing the data. Arrangement and construction of information was used to inter-

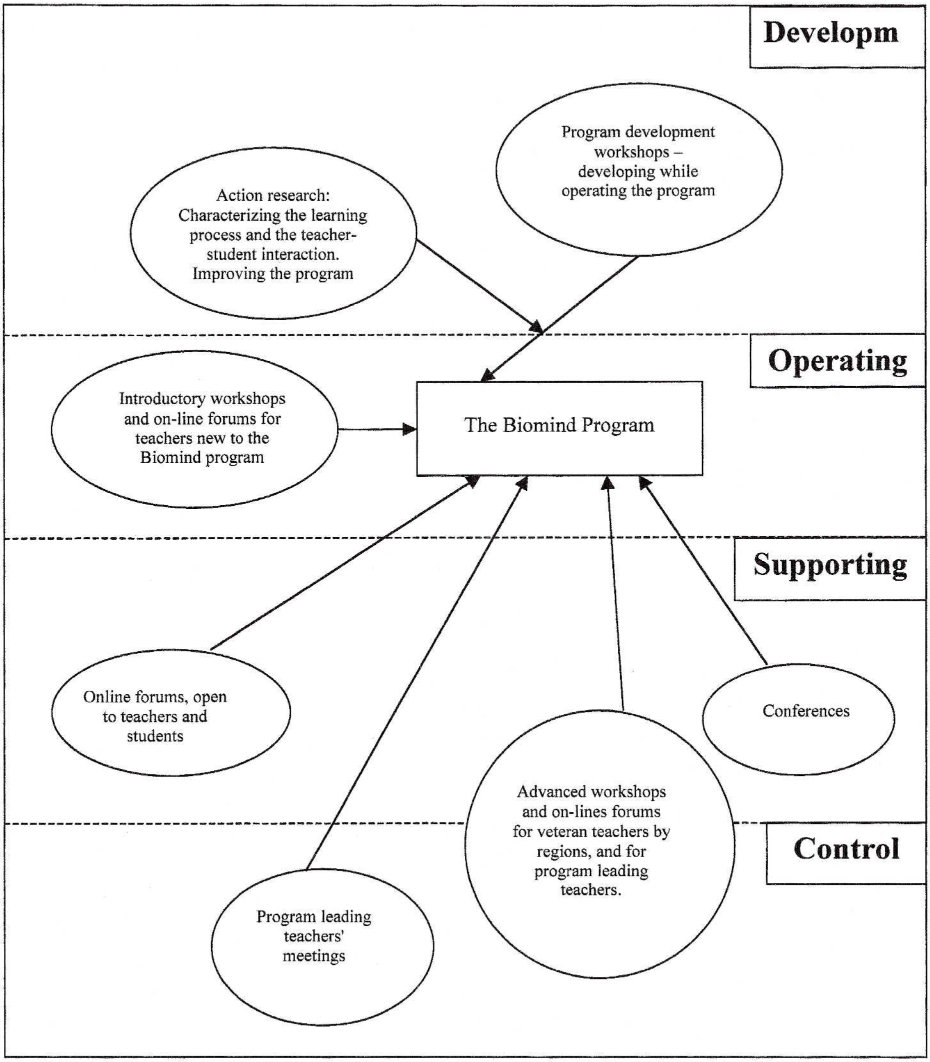

Figure 1. Implementation Model of the Biomind Program

pret and understand the meaning of the data (Pidgeon, 1996). Content analysis was based on characterization of activities conducted in the main frameworks accompanying curriculum implementation. Content analysis focused on characterizing the contribution of the framework to curriculum implementation, to teachers' comprehension of the open inquiry process, and to coping with teaching difficulties arising in guiding students through this sort of inquiry. Interviews have been conducted with teachers whose comments were quoted during "real-time" activity. This was done to verify that the "real-time" comments still hold after some time and that the content analysis is valid. Data analysis was done using the thoughts and ideas expressed by at least ten different teachers. Data collection through long-term activities contributed to the validity of the research (Anfara,

Brown, & Mangino, 2002). Data analysis was confirmed by two researchers, in addition to the author of this article.

Findings

This chapter presents the different aspects comprising the infrastructure that supports the curriculum implementation. For each aspect comprising the infrastructure, the activities conducted within it and evidence provided to support its unique contribution to the Biomind program implementation are presented. Later on, I shall also quote comments by teachers regarding the aspect's contribution to teachers' own understanding of the essence of open inquiry, and their ability to cope with the difficulties of teaching open inquiry.

Developing the Curriculum

The program was initiated by an ex-teacher who had thirty years of experience in teaching and served as the assistant for the national supervisor of biology. A team of thirty high school teachers joined the ex-teacher to build the program. The team of thirty teachers who developed the Biomind curriculum met once every two weeks for eight-hour workshops, two months before the beginning of the school year. Thus, the curriculum preparation began two months prior to the onset of the Biomind program. The teachers formulated the requirements that the program would place on students, and wrote draft instructions for the students. Inquiry activities were carried out in classes according to the instructions given to students, and their products were brought to the teachers' team for assessment, correction, and rethinking. The program instructions were changed and improved by the teachers during the first three years of operation. In general, it could be said that at every turning point (such as, checking students' proposals, students' primary portfolios, or a mock examination), the teachers' activity was characterized by rethinking the whole program and its different aspects.

Participating teachers have stated that developing and running the program in parallel by a teaching staff was of great contribution to the program: Real quotations from their expressions will be used as examples of their feelings about the program, followed by pseudonyms, such as in the following examples:

> *The meetings enabled mutual feedback and program development by many experienced teachers" (Shmuel). "Developing the program while teachers were actually applying it was an enormous contribution to the formation of the program. We improved it as we went along. There's no doubt that a brainstorming of thirty teachers, with all the diversity of ideas, will exceed the achievements of one genius. Feelings of cooperation and support were also very contributive in constructing the program. At the bottom line – it was fun (Nurit).*

Participating teachers have also stated that developing and operating the Biomind program enhanced their understanding of the open inquiry process:

> *At first, I was not very focused on it and rather confused by the uncertainty of the open inquiry process. By the end of the program development process, I felt that I have advanced in my understanding of the essence of inquiry as well as my ability to cope with uncertainty (Hatib).*

Regarding the contribution of the program's development process to teachers' difficulties in coping with teaching open inquiry, Esti has stated that:

> *The meetings enabled us to formalize and clarify subjects and concepts of inquiry*

teaching that seemed clear before, but, as it turned out, it needed further clarification, such as 'control' and 'inquiry question.'

Teachers have also mentioned the contribution of the the program development process in understanding the essence of the teacher-student relationship in open inquiry:

Professionally, the program has sharpened my conception of inquiry learning as independent student learning (Tzipi).

Nurit added:

I mostly learned about myself, on the spectrum between 'teaching' and 'facilitating', and on the spectrum between 'demanding' and 'letting go'.

Teachers commented that the group's work was important, because their awareness of both student and teacher difficulties with the open inquiry process enabled them to combine supporting elements for learning and teaching into the program as it was being created:

Every teacher brought his/her own experience and ideas and slowly a group was formed, acting at times as a forum for support and advice. For example, deciding that students would have an opportunity to correct as they go along the inquiry process was very helpful. This decision was followed by a considerable improvement of learning among all students (Naomi).

Dvora added to this:

Participating in curriculum development has taught me the importance of allowing students to correct their learning outcomes. It's important to write students advancing remarks that increase the element of correction in education (Dvora).

Action Research

For three years, the Biomind curriculum was constructed as it was being operated. During these years, curriculum components were experimented with and improved. These improvements were carried out making use of the feedback and lessons that were brought back from the teaching field by teachers participating in scheduled program development meetings, and by means of an action research conducted by a small group of teachers working for the development of the program. The action research made it possible to gather evidence in a controlled and systematic fashion regarding the open inquiry process in qualitative terms. The action research applied the model of practical-cooperative action research (Elliott, 1997). In this model, collection and analysis of data is performed cooperatively among classroom teachers and university-based academic staff. The teachers participated in the process of planning the research and determining the research goals, conducting the research, and examining the ways in which significant curriculum changes could be implemented (Elliot, 1997). The Biomind program action research characterized the open inquiry as a dynamic inquiry learning process, where learning is a process of continuous and renewed thinking that involves flexibility, judgment, and contemplation, in response to changes that occur in the course of the research. Zion et al. (2004b) found that the main criteria for characterizing dynamic inquiry are: learning as a process, changes occurring during the research, procedural understanding, and affective points of view, such as, curiosity, frustration, surprise, perseverance, and having to cope with unexpected results. Characterizing the dynamic inquiry process in the Biomind program has

resulted in adding emphases in curriculum instructions leading students and teachers to experience inquiry with perspectives of critical thinking and change, reflective thinking about the process and affective aspects, such as curiosity, that are expressed in situations of change and uncertainty (Zion et al., 2004b).

The action research also presented a qualitative view of a teacher-student association within the context of dynamic inquiry (Zion & Slezak, 2005). The action research showed that dynamic inquiry did not separate teaching from learning, but created a learning community of teachers and students that was crucial to the success of the inquiry process (Zion & Slezak, 2005). This research further suggested a method of documenting the dynamic inquiry process, for further curriculum improvement. This method of documenting the dynamic inquiry process included a graphic flow-chart, emphasizing the process orientation, including changes, and a table of stages of dynamic inquiry, emphasizing reasons for these changes (Zion et al., 2004b). This method of documenting the dynamic inquiry process can serve as a solid basis for students' identification of the inquiry process learning, reflection on their learning process, and development of metacognitive and scientific skills.

In addition to the action research contributing to characterizing the inquiry process and improving the Biomind program, it has also enhanced participating teachers' understanding of the inquiry process. Michal mentioned the insights she gained into the essence of the inquiry process:

> *I recalled our action research meeting, where we said we were interested in studying procedural aspects of inquiry, such as control and repetition... In retrospect, I realize that the action research and its summation have opened my eyes to the importance of the inquiry process as a whole and not as detached stages.*

Nurit mentioned the dynamic element of the inquiry process characterized by the action research:

> *Many times, when I would be sitting with students thinking 'this experiment is going nowhere', I would suddenly flash back to the action research and remember that 'inquiry is a dynamic process, it is OK for things not go as planned'... that would calm me down.*

Experiencing methodical educational research improved the teaching of inquiry, as one teacher, Efrat, explained:

> *Before I did the action research, I would not reflect very deeply on my work. Now I understand there is nothing like introspection and consciousness rising to improve teaching, and to advance professionally in general. The action research has taught me, amongst other things, to document the teacher-student encounter. I walk around with a notebook and actually record my encounters with students. It helps me facilitating the inquiry process. I can link students to their previous stages and know how to help them cope with difficulties arising during the inquiry process.*

Dvora added that the action research was important in encouraging participants to "*expose themselves, show flexibility in teaching, and develop patience for a new curriculum full of uncertainty.*"

Teacher Training

Following the first three years of the Biomind program, its official rationale and instructions were published. Although the spirit and demands of the program

were widely circulated, the Ministry of Education decided that any teacher following the Biomind curriculum must participate in teacher workshops. To facilitate this decision, two kinds of workshops were set up. The first is an introductory workshop intended for teachers new to the program. The second is advanced workshops for veteran teachers. The teachers that have been guiding both kinds of workshops, took part in developing the Biomind program, and are henceforth referred to as program leading teachers.

Introductory workshops

Introductory workshops are intended for teachers new to the Biomind program. In these workshops, the teachers learn the principles of open inquiry teaching and the principles of the new program. The workshops also provide scientific and pedagogical support to assist teachers in facilitating their students' open inquiry processes. The teachers are offered ways of facilitating students in the laboratory and in the field, and facilitate them through portfolio construction. Teachers gain practical experience of open inquiry in these workshops. They are asked to locate an interesting phenomenon in the field, and write a proposal for open inquiry into this phenomenon, just as their students are required to do. An emphasis is given on the analysis of student output that the teachers brought in from their classes. Judy, a participating teacher, has stated that:

> *The workshop is very helpful in understanding the requirements of the Biomind program. The workshop supplies useful tools and confidence for open inquiry teaching.*

Participating teachers stated two main contributions of the workshops in their understanding of the essence of open inquiry and the difficulties students experience with it. One was stated by Tzila:

> *The fact that we, the teachers, face the same experiences of inquiry as our students helps us understand their difficulties in phenomenon identification, question phrasing, and scientific writing.*

Furthermore, as Leah has stated, "I have learned that even when results do not exactly meet expectations, the students can still have a significant learning experience." The second significant contribution of the workshops was the teachers' ability to share their problems and dilemmas with other workshop participants. Ilana said:

> *I think it is very important that participants arrive at the workshop prepared, so that they can use the forum to analyze personal teaching examples and extract from these useful lessons about inquiry teaching.*

Advanced workshops for veteran teachers

The advanced workshops for veteran teachers are intended for teachers familiar with operating the program. These workshops are held at a regional level. Teachers are required to participate, based on the view that a teacher's professional development is an ongoing process that occurs throughout their career, especially, when faced with a complex constructivist task (Darling-Hammond, 1998; Putnam & Borko, 2000). Most of the work done in these workshops is cooperative review of students' inquiry proposals, examining the biological basis of inquiry questions and the logical relations between them, as well as experimental procedures and their relevance to the proposed inquiry. Participating teachers share biological and procedural ideas. Involving teachers in such pedagogical support

groups is beneficial for several reasons. These groups can assist teachers in understanding the essence of the open inquiry process, and supply them with constant scientific and pedagogical support regarding their students' inquiry projects.

Efrat, a program leading teacher of one of the groups, spoke of the main characteristics of the advanced workshops for veteran teachers:

Teacher discourse mainly concerned inquiry crossroads where students raised questions and wondered. Most discussions in the veteran teachers' group took place at the first stages of inquiry and nearing its end, and concerned choosing a phenomenon on which to base the inquiry. The discussions revolved around locating scientific material, because both teachers and students experienced difficulties in finding information and understanding foreign language material.

The discussions in advanced workshops for veteran teachers also involved experimental procedures, methods of locating logically related inquiry questions, and the Discussion chapter of the inquiry summary, which logically synthesizes all of the inquiry results. It was found that knowledge sharing is a very central aspect in teacher-student relations. Examples of teacher-student conversations were presented in the workshops as a basis for reflective thinking about the inquiry teaching in the Biomind program. Efrat admitted that the group activities were of great contribution to her teaching skills as well. She gained many new ideas, biological and technical, that improved her inquiry teaching. She also stated:

I was overwhelmed by teachers' willingness to help each other out." Efrat said that besides the face-to-face meetings, "teachers tend to call the program leading teacher or a teacher colleague on the phone and consult on different aspects of inquiry.

Michaela also added:

I'm excited every time in the meetings, seeing how much teachers contribute to one another in phrasing inquiry questions. These meetings have a very positive feel and attitude. Teachers leaving them saying 'it's great that I came here, I learned something'. That's excellent.

Both types of workshops comprised a support infrastructure for teachers, but also acted as an apparatus for controlling curriculum rationale and standardization, which is necessary for the proper implementation of a curriculum in a national-scale program. One example of this can be seen in a remark by Judith, a program leading teacher, to Nilly, one of the teachers attending her group:

In observation questions, when there is no researcher intervention, we ask 'what is the connection between this and that', not 'how does this affect that'. When there is intervention, in the field or in the lab (like causing or stopping pollination), we refrain from yes/no questions beginning with 'does so and so'. Besides that, you're doing a great job!

A conversation between Judith and Yaffa, a teacher, gives another example of the program leading teacher's role in preserving the principles of the Biomind curriculum:

Do Biomind programs instructions require one of the questions to include examination by direct observation?" (Yaffa)

There's no obligation to include direct observation in the inquiry process. It is highly recommended to do so. In any case, you're required to describe the phenomenon on which the inquiry process was based at the Introduction of the written report (Judith).

Table 1

Program Leaders' Discussion: A Case Study

Program leader's name	Quote from on-line program leader discussion group	Analysis in context of program leaders' comprehension of the essence of the open inquiry process	Analysis in context of understanding the ways teachers cope with the difficulties of open inquiry
Ruthy	Even if I agree with Dvora, that the researched phenomenon could have been discovered by reading, watching a film or class discussion, we must still demand that the phenomenon be observed in the field. As for the *Oleander*, it is unclear whether the literature unequivocally claims that it is not eaten by insects. A note to Tzipi: Observing a chewed plant next to an untouched *Oleander* does not prove anything. If we read about such a phenomenon and then observed the eaten and uneaten plants in the field, we may then raise inquiry questions.	A program leader emphasizes the importance of the literature in phrasing the phenomenon observed in the field, as a basis for asking a fruitful inquiry question.	A program leader expresses her opinion of the importance of teachers facilitating their students to identify all components of their observed phenomenon and back it up by proper literature reference.
Judith	I can see that you're going easy on students while I'm being harsh. Some insects (*Oleander hawkmoth*) feed on the *Oleander* and are immune to its poison, and can spot chewed *Oleander* leaves in the field. The students in question wish to study the toxicity of the *Oleander* of which they have read about in the literature but which they cannot observe in the field. I gather from your replies that I should approve the subject.	A program leader suggests she may be too harsh on her students in demanding that all aspects of the phenomenon be observed by them in the field.	Students find it hard to identify all aspects of the phenomenon in the field. Even if they are familiar with it from the literature.
Ruthy	I think you reached an erroneous conclusion from the replies. Toxicity cannot be observed directly in nature. But if literature implies that the *Oleander* is not eaten by insects, then observing eaten and untouched leaves is one way to examine toxicity. If the literature states that it is eaten by some insects, then it is impossible to compare eaten and uneaten *Oleander*.	A teacher explains how to identify a phenomenon in the field whose characteristics were noted in the literature.	Students find it hard to identify all aspects of the phenomenon in the field, even if they are familiar with it from the literature.
Judith	The problem is that the students' inquiry question is: What is the connection between the presence of *Oleander* leaf extract in sugar solution on ant mortality? In order for that to qualify as an inquiry question, some link should be made from observation or the literature between ants and *Oleander*. In describing the phenomenon, the students did not mention ants at all. So I totally don't agree with this inquiry project.	A program leader emphasizes that inquiry questions must be directly related to the phenomenon observed in nature.	Students find it hard to make a direct connection between the phenomenon in the field and the inquiry questions.
Ruthy	You're right. Judging by the inquiry question, this project is worthless.	A program leader agrees that the inquiry questions must be directly related to the phenomenon observed in nature.	Students find it hard to make a direct connection between the phenomenon in the field and the inquiry questions.

Table 1

Program Leaders' Discussion: A Case Study (continued)

Program leader's name	Quote from on-line program leader discussion group	Analysis in context of program leaders' comprehension of the essence of the open inquiry process	Analysis in context of understanding the ways teachers cope with the difficulties of open inquiry
Judith	Students posted a question to the teachers' discussion group, message #223. They chose a subject and asked our assistance in finding a phenomenon to fit the subject. I've answered students many times before that they must first locate a phenomenon and then look for material and raise questions. A second problem: A teacher is working with a student on the toxicity of *Oleander*. The phenomenon she describes: *Oleander* leaves are not being eaten. I've confronted a teacher once before and told her that uneaten leaves are not a phenomenon. Should I disqualify the suggested phenomenon?	Program leader asks her colleagues' assistance in clarifying herself what is a valid phenomenon on which to base an open inquiry process.	A program leader emphasizes that teachers find it difficult to facilitate students in locating an inspiring phenomenon that would lead to an inquiry question.
Tzipi	Is a description of uneaten *Oleander* leaves and eaten leaves of other green plants growing nearby considered a phenomenon? We have a location, an occurrence, a comparison, and an entire organism. So…	A colleague program leader mentions the importance of the comparative aspect in locating a phenomenon.	A program leader suggests to a teacher to turn the attention of a student, who had come across something of interest, in the direction of phrasing and emphasizing the observed phenomenon by comparison with its surroundings.
Nurit	In answer to Judit's first comment: I believe there is no doubt about it. As program leaders we cannot cooperate with such requests. We should send the students back to their teachers and refrain from answering them in the discussion group. That would be counter-educative for both students and teachers.	In open inquiry it is very important that the process be based on a phenomenon. The teacher plays a critical role in helping the student locate an inspiring phenomenon.	A program leader emphasizes that teachers find it difficult to facilitate students in locating an inspiring phenomena that would lead to an inquiry question.
Dvora	I totally agree with Nurit and Tzipi's responses. It is important to distinguish between cases. It is very important to clarify to students what is a complete and proper thought process of open inquiry, and it is also important not to supply them with phenomena for questions. That would be intellectually and pedagogically harmful. Specifically in the case of the *Oleander*, the response may have been a bit harsh. Sometimes students need to be facilitated to use literature so they can base some discussion about what they see in the field.	A program leader emphasizes the importance of the literature in phrasing the phenomenon observed in the field, as a basis for asking a fruitful inquiry question.	A program leader expresses her opinion of the importance of teachers directing students to support their process of locating a phenomenon in the field by proper reference to the literature background.

Program Leading Teachers

The program leading teachers, who guided the different teachers' groups of the Biomind program, met twice a year. The national biology studies supervisor participated in these meetings. Problems common to all groups were discussed in those meetings. The group of program leaders is actually the administrative body in charge of the Biomind program. The leaders can monitor what goes on in classes and understand general problems of program implementation, thus deciding on appropriate alterations. Besides face-to-face meetings, program leaders use a networked discussion group to consult one another on different aspects of program implementation. Most discussions concerned the difficulties of program leaders in explaining to teachers how to facilitate students in phrasing observations and logically related inquiry questions. Table 1 gives an example of program leaders' discourse regarding the identification of a phenomenon in the field and phrasing inquiry questions. Table 1 also presents an analysis of how program leading teachers comprehend the essence of open inquiry and the difficulties they, and the teachers they guide, encounter.

Dvora stated that being a program leading teacher made her feel she's *"taking part in shaping the program."* On several occasions when interviewed, she said:

> *I feel a responsibility for the program and its success and try to influence its spirit. Participating in program leaders' meetings and the virtual discussion group is an interesting part of that.*

Program leaders stated that guiding helps them understand the spirit of the program. Nurit, for example, has learned that "good inquiry is one where all questions are inter-related." Dvora emphasized the contribution of her guidance work to her understanding of the concept of logically-related inquiry questions:

> *Following my work as a program leading teacher, I am now more confident in what I do, and at the same time more aware of traps along the way. For instance, I think that the inquiry proposal was one of the greatest ideas that came up during program development, and I feel it would be a serious mistake if program leaders decide to drop it. I think writing an inquiry proposal must be done cooperatively by teacher and students just like any other stage of open inquiry. As a program leading teacher, I understood that the teacher's role in open inquiry is critical because only few students displayed initiative and independence in their role. This, I understood only after I became a program leading teacher.*

Asynchronous On-line Forums

The implementation of the Biomind program is facilitated by several forums. A students' forum functions as a stage on which students present their difficulties and seek the advice of teachers and peers. A teachers' forum, open to all, is a stage for teachers to consult with colleagues and with the national biology studies supervisor on issues regarding the Biomind program.

In the students' open forum, students required assistance mainly with searching for scientific information, finding experimental techniques and procedures, and phrasing inquiry questions (Zion, in press). The three most frequent areas that were discussed in the teachers' forum were technical and procedural aspects of experimentation,

bureaucracy, and phenomenon identification in nature (Zion, in press). In addition, issues, such as, inferring and discussing, logical progression of the inquiry process, scientific writing, teacher-student interaction, reflective thinking, affective points of view, and forum administration were raised in the forum discourses.

There were expressions of gratitude from students thanking the forum:

The site is wonderful, extensive, and full of knowledge and information about the charming program. Well done! And to you, Judith (the forum manager), we wish to express our special thanks for your efforts and willingness to help such helpless students as ourselves. Our presence in the site is assured (Students' forum message No. 130).

In students' forum message No. 444, a student wrote:

Thank you all for the encouragement, it's all right now! I'm sure all the depressed ones will eventually get an 'A' grade.

The importance of the teachers' forum in the implementation of the Biomind program was brought up in the forum itself by one of the teachers, wondering whether the forum encourages constructivist learning:

Student discussions contain so many requests in their posted messages, that I wonder how much of the work was really done by students. Instead of using search engines, they use us, and we give even more than they asked for. What do you think? (Irit.)

Dvora and other teachers discussed this issue:

I sometimes, though rarely, feel just like you. In most cases, though, I feel that our help really is necessary. The Biomind program demands a lot from students, and many times the teachers themselves find it difficult to help. What I think is important – and we have Judith to thank for that – is the creation of a dialogue with students who come up with questions. I think it is especially important to find readable English material for them, as non-English speakers may get lost:

I totally agree with Dvora. Information handling is a profession these days, and there's no need to add to the students' difficulties. The questions that Judith, as forum manager, asks the students before she answers them, encourages thinking and does not digest the material for them. (Rachel).

I also agree with Rachel and Dvora. Even when Judith points a student to a source of information or simply sends them an article, they still have enough work to do. And don't forget the goal is also to help teachers. I think that a student approaching us with a problem must receive our assistance. (Ruthi).

I always enjoy reading what Judith writes to students, how she supplies them with crutches but leaves them to take the steps by themselves. I agree that they really need so much help and support, and it's great that someone finds the time to do it professionally. Besides, it's fun to hold discussions about forum roles here in the forum (Tali).

I agree with everything that's been said in response to Irit's 'complaint' and would like to add that Judith helps us in two ways. First, she supplies us and our students with very important information that may be difficult for teachers to obtain, even though we'd like to. Second and maybe more important, she shows us how to deal with the students: what to ask, how to phrase, etc. Judith, keep helping us all, and keep up the good work! (Yafa).

In addition to students' and teachers' forums, there are other forums, to which access is limited by password. These closed forums facilitate new teachers in the Biomind program, and veteran teachers involved in advanced workshops in different

parts of Israel, and for program leading teachers. These closed forums concern administrative issues regarding the program, difficulties in inquiry teaching, and serve as a platform in which teachers present their students' inquiry proposals for peer examination.

Conferences

Shemuel, a program leading teacher, emphasizes that curriculum implementation requires face-to-face teachers' meetings, where important discussions of program structure and principles can be held, and lessons for improvement can be learned:

> *The program underwent several interpretations and compromises due to difficulties in teaching. When this happened, teachers began to feel insecure and raise important questions. Excuse me for not believing in virtual meetings. I need to see the people I'm talking to and address everything they say. On the last virtual meeting and following it, I raised many issues with much urgency, but have hardly received any feedback from you.*

Every year a conference is held for the entire Biomind program community. Guest scientists speak at the conferences to enrich teachers' scientific knowledge and give ideas for observations and controlled experiments. Teachers hold workshops and present inquiry processes that occurred in their classes and students' learning products. They also bring up teaching difficulties and suggest solutions. A panel for all program teachers discusses one of the most popular questions of curriculum implementation. Tali referred to the contribution of conferences to the teachers:

> *I came out of the conference with a great feeling. It was well-organized and varied, interesting, gave us many teaching ideas, expanded our horizons and made us feel we belong; it also taught us there's much more room for teachers' professional development. We can't lie back or contently wade in our old and familiar pool. Many thanks to everyone who contributes to this conference.*

Rachel and Ruthy, leading program teachers, have added to this:

> *Besides the mutual contribution of ideas, it was also important to hear critique of the program.*

The final panel aroused many responses from teachers following the conference, especially a panel discussion of 'what is a good inquiry project in the Biomind program'. Four teachers spoke in the panel, explaining the criteria for assessing a good inquiry project, followed by a discussion with audience participation.

> *The conference was very successful. This impression was shared by everyone I spoke to. The scientific lecture, I think all agree, was a great success… as for the panel, I think it brought up interesting points, even ones I was not in total agreement with. I think the discussion that began in the panel should continue (Dvora).*

Nurit added to this, mentioning the importance of a follow-up discussion accompanying the panel, occurring in the teacher groups and facilitated by program leaders:

> *The issue discussed on the panel is of great concern to us, but not all teachers found it entirely clear. A teacher new to the Biomind program can not yet see the connections and conflicts we discussed. This echoes back to us, as program leaders, and emphasizes our role. The conference has proved that the Biomind program family is alive and kicking!*

Mira has also stated that the discussion did not end in the panel:

> *The trouble with these panels is that just as things warm up, it's time to disperse. It's very important to clarify the issues raised in the panel, to give a concise summation of things said.*

Disscussion

The model of the Biomind program implementation composed of four interactive domains, which are shown in Figure 1: Development, Operating, Supporting, and Control.

The Development Domain

Despite the growing consensus regarding the value of inquiry-based teaching and learning, the implementation of such practices continues to be a challenge. Hurdles include state-mandated high-staked examinations, other time–related constraints, teachers' perceptions of their students' expectations and abilities, and teachers' fear of launching into the unknown (Trautmann & Makinster, 2005). In order to overcome these difficulties, Tamir (2004) summarized forty years of experience in curriculum development and implementation in the world and particularly in Israel, and concluded that curriculum development and implementation should not be viewed as two separate processes, but rather as one interactive process. According to this vision, the support infrastructure for implementing the Biomind program was constructed. At the first stage, workshops were held where teachers developed the program as it was being implemented. This team was able to improve the program in the light of lessons learned by class experience. The participation of some of the developing teachers in an organized action research also contributed to improving the program and better understanding its characteristics. Thus, teachers' reflective discussions and the ongoing action research contributed to the developing and improving of the Biomind program through a long term process.

The Operating Domain

Once the Biomind curriculum was inaugurated in print, many teachers joined the program. The publication of two pamphlets, a teacher pamphlet and a student pamphlet, detailing the rationale, principles and requirements, might give the impression that further workshops are unnecessary. As new teachers continue to join the program, some of them being veteran teachers with many years of experience, who may find it difficult to accept change, it is clear that implementation workshops are a necessity. The need arose to establish a framework for introducing new teachers into the program, clarifying its rationale and preparing them to teach by its principles.

Although open inquiry offers compelling opportunities for science teaching, there are many challenges to the successful implementation of inquiry-based learning. Edelson, Gordin, and Pea (1999) focused on five of the most significant challenges to the successful implementation of inquiry-based learning among students. These challenges are: motivation, accessibility of investigation techniques, scientific background information, management of extended activities, and practical constraints of school learning environment. A critical question for science educators is how to provide professional development that will help teachers overcome the considerable challenge they face in implementing open inquiry in their classrooms. Engaging students in truly open-ended inquiry requires a teacher to have appropriate pedagogical tools, confidence, an understanding of science in its social context, experiences with scientific inquiry, and agreement with the goals of reform-based science education standards (Avery & Carlsen, 2001; Barnett & Hodson, 2001; Bencze, Bowen, & Alsop, 2006). These elements of professional development can successfully be attained by teachers only when they actively participate in workshops that are long-term, schoolbased, collaborative, focused on student learning, and linked to curricula (Darling-Hammond &

Sykes, 1999; Loucks-Horsley, Hewson, Love, & Stiles, 1998). The introductory workshops and on-line forums for teachers, new to the Biomind program, emphasize these aspects, hence their importance in program implementation.

The Supporting Domain

A quality professional development program is never ending and ever-evolving from a deep base in foundational insights. As Kennedy (2001) notes, teachers need to be supported to develop their professional skills and knowledge as a life long activity, hence the importance of the advanced workshops and on-line forums for veteran teachers, and conferences in program implementation.

According to Tamir (2004):

> *Curriculum implementation, in general, is the process of putting ideas and materials into practice, beginning with dissemination and ending with utilization and evaluation. Implementation in its general sense involves two additional processes, namely, adoption and adaptation. Adoption refers to the decision to use a particular innovation. This decision is followed by actual utilization of the materials in the classroom. The utilization may be seen in terms of two modes: fidelity: using a particular innovation in a way which corresponds to the intentions of the developers; and adaptive: modifying and further developing of the innovation to meet special local needs (p. 283).*

The fidelity mode was expressed throughout the different aspects of the Biomind program implementation model. While introductory workshops operated as a basis for teachers' professional development, the advanced workshops and forums for veteran teachers, as well as conferences, were significant factors in maintaining and extending this development. The heightened discussions which emerged throughout the different program implementation aspects, bringing to the surface problems and dilemmas of program implementation, were important in reinforcing teachers' comprehension of program rationale.

The adaptive mode of the Biomind program implementation, on the other hand, was expressed in the fact that the issues brought into discussion were the pedagogical reality and teaching experiences of teachers in their classrooms. Moreover, teachers (especially veteran teachers) were not only bringing up problems, but also suggesting pedagogical solutions to help their colleagues. Westbrook and Rogers (1996) noted the importance of discussing teachers' pedagogical reality to their professional development:

> *As value is placed on what happens in the classroom, and time is provided for exploration and growth, teachers may begin to view professional change as a positive and rewarding venture (p. 38).*

The Control Domain

The advanced workshops for veteran teachers and online forums not only enabled pedagogical support and long-term professional development for teachers, but also supplied an infrastructure for control of the Biomind program. Here, the program leading teachers played an important part in maintaining and controlling the rationale of open inquiry in the Biomind program. The existence of such a control aspect, based on the program leading teachers, contributed to sustainability, and monitoring the capacity of the reform (Bybee, 1997). Program leading teachers operated as sensors exposed to the teachers' adoption and adapta-

tions processes. Program leading teachers synthesized teaching and learning, which evolved through processes discussed in different program frameworks and extracted valuable lessons that improved the curriculum.

In order to feel empowered to make changes, teachers need opportunities to reflect on their experiences, beliefs, and roles without fear of negative judgments or reactions (Westbrook & Rogers, 1996). The fact that teachers were at the forefront of change, while officials and academics of science education kept to the back ground, giving the floor for the program leading teachers, probably enabled control, professional development, and openness, and further development of the innovation.

Parker (1997) explained that leaders should play an important role in educational reforms, especially those reforms that "are long-term, involve many unanticipated surprises, and can often be messy, uncomfortable, and frustrating" (p. 244). As uncomfortable and frustrating events may be part of an open inquiry process, the necessity for leaders that drive the implementation vehicle is crucial. These leaders need not have a vision of what the future should be, as an open inquiry learning process is a dynamic and exciting search for the understanding of patterns. Biomind program leaders are likely to match the five dimensions that were mentioned by Loucks-Horsley et al. (1998): (1) seeking partnerships in and voice of the educational community; (2) applying vision and values to their decisions; (3) developing knowledge bases, increasing capacity and encouraging risk taking; (4) knowing how educational systems work; (5) having a well developed sense of humor and use of language that signals their empathy to others. It would be interesting to research whether program leaders function by these characteristics, especially in cases where they have to make decisions and supply constructive criticism.

Looking Ahead

Research findings show that, in each aspect of program implementation, there is improvement in teachers' professional pedagogical knowledge on the teaching of open inquiry. Teachers are more able to comprehend the essence of open inquiry and to cope with the difficulties of teaching open inquiry. Results also show that many of the activities conducted in the different aspects of the Biomind program implementation infrastructure concern finding scientific information, finding inquiry procedures, finding phenomena to inquiry, and asking logically related inquiry questions. Intensive discussion of these issues in different frameworks indicates that these issues are central to the open inquiry process. Extensive discussion of these issues indicates that the Biomind program implementation infrastructure has created a wide educational community united by a common goal, whose members enrich and support each other. It is reasonable to assume that due to the open character of the inquiry process on which the Biomind program is based, and due to the complex teacher-student interaction it involves, different issues will continually be brought up in all frameworks supporting the program. This notion makes the overall infrastructure of the program implementation relevant and vital to maintaining the activity of the educational community operating in the program.

It would also be interesting to examine at a future time how the entire Biomind program teaching community was affected by their involvement in the program, with regards to their coping with others teaching aspects of the general (non-inquiry) biology curriculum. The biology curricula are affected from different pedagogical theories that surface from time to time, from the rapid pace of tech-

nological development supporting educational processes, and from the lightning-fast progress in the science of biology. It would be interesting to follow the evolution that the Biomind curriculum and its supporting infrastructure go through in the coming years, in light of future changes in society, technology, and biology, changes to which the Biomind program practitioners will have to respond.

References

American Association for the Advancement of Science (AAAS), Project 2061. (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

ANFARA, V. A., BROWN, K. M., & MANGINO, T. L. (2002). Qualitative analysis on stage: Making the research process more public. *Educational Researcher, 31,* 28-38.

AVERY, L. M., & CARLSEN, W. S. (2001). *Knowledge, identity, and teachers' multiple communities of practice.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, St. Louis, MO. [Web Resource] Available on-line: http://ei.cornell.edu/pubs/.

BARNETT, J., & HODSON, D. (2001). Pedagogical Context Knowledge: Toward a fuller understanding of what good science teachers know. *Science Education, 85,* 426-453.

BENCZE, L., BOWEN, M., & ALSOP, S. (2006). Teachers' tendencies to promote student-led science projects: Associations with their views about science. *Science Education, 90(3),* 400-419.

BERG, C. A. R., BERGENDAHL, V. C. B., & LUNDBERG, B. K. S. (2003). Benefiting from an open-ended experiment? A comparison of attitudes to, and outcomes of, an expository versus an open-inquiry version of the same experiment. *International Journal of Science Education, 25(3),* 351-372.

BYBEE, R. W. (1997). *Achieving scientific literacy: From purposes to practices.* Portsmouth NH: Heinemann.

BYBEE, R. W., & LOUCKS-HORSLEY, S. (2001). National science education standards as a catalyst for change: The essential role of professional development. In Rhoton, J., & Bowers P. (Eds.) *Professional Development Planning and Design.* Reston: NSTA Press, VA, 1-12.

DARLING-HAMMOND, L. (1998). Teacher learning that supports student learning. *Educational Leadership, 55(5),* 6-11.

DARLING-HAMMOND, L., & SYKES, G. (Eds.) (1999). *Teaching as the learning profession: Handbook for policy and practice.* San Francisco, CA: Josey-Bass.

DRIVER, R., ASOKO, H., LEACH, J., MORTIMER, E., & SCOTT, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher, 23(7),* 5-12.

DVIR, M., & CHEN, D. (2000). Inquiry learning in a greenhouse- learning environment – A research of theoretical and practical points of view using case study. In Nassa, P., Hativa, N., & Shwartz, Z. (Eds.) *The Research in Education and its implementation in a changing world.* Even Yehuda, Israel: Reches ,Part A, 288- 290 (in Hebrew).

EDELSON, D. C., GORDIN, D. N., & PEA, R. D. (1999). Addressing the Challenges of Inquiry-Based Learning through Technology and Curriculum Design. *Journal of Learning Sciences, 8 (3/4),* 391-450.

ELLIOTT, J. (1997). School-based curriculum development and action research in the United Kingdom. In Holligworth, S. (Ed.), *International Action Research,* (pp. 17-29). London: Falmer Press.

GOTT, R., & DUGGAN, S. (1996). Practical work: its role in the understanding of evidence in science. *International Journal of Science Education, 18,* 791-806.

HAURY, D. L. (1993). Teaching science through inquiry. In Gronlund, L. E. (Ed.) *Striving for excellence: The national education goals.* (Vol. 2, 71-77) Washington, DC: Educational Resources Information Center.

KENNEDY, K. (2001). The teacher quality debate: Focusing on the professional and personal dimensions. In Kennedy, K. (Ed.) *Beyond the rhetoric: Building a teaching profession to support quality teaching* (pp. 2-11). Deakin West, ACT: Australian College of Education.

KENNEDY, M. (1997). *Defining optimal knowledge for teaching science and mathematics* (Research Monograph No. 10). Madison: University of Wisconsin–Madison, National Institute for Science Education.

KHISHFE, R., & ABD-EL-KHALICK, F. (2002). Influence of explicit and reflective versus implicit inquiry-oriented instruction on sixth graders views of nature of science. *Journal of Research in Science Teaching, 39(7),* 551-578.

LIM, B-R. (2004). Challenges and issues in designing inquiry on the Web. *British Journal of Educational Technology, 35(5),* 627-643.

LOUCKS-HORSLEY, S., HEWSON, P. W., LOVE, N., & STILES, K. E. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press, Inc.

National Research Council. (1996). *National Science Education Standards.* Washington, DC: National Academy Press.

National Research Council. (2000). *Inquiry and the National Science Education Standards.* Washington, DC: National Academy Press.

OSBORNE, J. F. (1996). Beyond constructivism. *Science Education, 80,* 53-82.

PARKER, R. E. (1997). Comprehensive school and district restructuring of mathematics: principles and caveats. In Friel, S. N., & Bright, G. W. (Eds.) *Reflecting on our work: NSF teacher enhancement in K-6 mathematics,* (pp. 237-246). Lanham, MD: University Press of America.

PIDGEON, N. (1996). Grounded theory: Theoretical background. In Richardson, J. T. R. (Ed.) *Handbook of Qualitative Research Methods.* Leicester, (pp. 75-85). UK: The British Psychological Society Books.

PUTNAM, R., & BORKO, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29(1),* 4–15.

RAGER, K. B. (2005). Self-care and the qualitative researcher: When collecting data can break your heart. *Educational Researcher, 34(4),* 23-27.

ROTH, W.M. (1999). *Scientific research expertise from middle school to professional practice.* Paper presented at the Annual Meeting of the American Educational Research Association, Quebec, Montreal (April, 1999).

RUDDUCK, J., & HOPKINS, D. (1985). *Research as a basis for teaching: Readings from the work of Lawrence Stenhouse.* London: Heinemann.

SCHAUBLE, L., KLOPFER, L. E., & RAGGHAVAN, K. (1991). Students' transition from an engineering model to a science model of experimentation. *Journal of Research in Science Teaching, 28,* 859-882.

SINGER, J., MARX, R. W., & KRAJCIK, J. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. *Educational Psychologist, 35(3),* 165-178.

STENHOUSE, L. (1975). *An* introduction *to curriculum research and development.* London: Heinmann.

TAMIR, P. (2004). Curriculum implementation revisited. *Journal of Curriculum studies, 36(3),* 281-294.

TAMIR, P., STAVY, R., & RATNER, N. (1998). Teaching science by inquiry: assessment and learning. *Journal of Biological Education, 33,* 27-32.

TILGNER, P. J. (1990). Avoiding science in the elementary school. *Science Education, 74,* 421-431.

TRAUTMANN, N., & MAKINSTER, J. (2005). *Teacher/Scientist partnerships as professional development: Understanding how collaboration can lead to inquiry.* Paper presented at the 2005 International Conference of the Association for the Education of Teachers of Science, Colorado Springs, CO. (January 19-23).

UNO, G. E. (1997). Learning about learning through teaching about inquiry. In McNeal, A. P., & D'Avanzo, C., (Eds.) *Student-Active Science: Models of Innovation in College Science Teaching,* (pp. 189-198). Fort Worth: Saunders College Publishing.

WESTBROOK, S. L., & ROGERS,L. N. (1996). Beyond infomercials and make-and-take workshops: Creating environments for change. In Rhoton, J., & Bowers, P. (Eds.) *Issues in science education,* (pp. 34-39). Washington, DC: National Science Teachers Association.

WHITE, R.T. (1988). *Learning Science.* Oxford: Blackwell.

WINDSCHITL, M. (2002). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87,* 112-143.

WINDSCHITL, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87(1),* 112-143.

YAGER, R. E. (1991). The constructivist learning model. *The Science Teacher, 58(6),* 52-57.

ZION, M. (in press). On-line Forums as a 'Rescue Net' in an Open Inquiry Process. *International Journal of Science and Math Education.*

ZION, M., SHAPIRA, D., SLEZAK, M., LINK, E., BASHAN, N., BRUMER, M., ORIAN, T., NUSSINOWITZ, R., AGREST, B., & MENDELOVICI, R. (2004a). Biomind - A new biology curriculum that enables authentic inquiry learning. *Journal of Biological Education, 38(2),* 59-67.

ZION, M., & SLEZAK, M. (2005). It Takes Two to Tango: In dynamic inquiry, the self-directed student acts in association with the facilitating teacher. *Teaching and Teacher Education, 21,* 875-894.

ZION, M., SLEZAK, M., SHAPIRA, D., LINK, E., BASHAN, N., BRUMER, M., ORIAN, T., NUSSINOWITZ, R., COURT, D., AGREST, B., & MENDELOVICI, R. (2004b). Dynamic, open inquiry in biology learning. *Science Education, 88,* 728-753.

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